

**In the Claims:**

- A. Kindly cancel Claims 5 and 15, without prejudice.  
B. Kindly amend Claims 1, 6, 11, and 16, as follows.

1. **(currently amended)** A method of fabricating a semiconductor device, having a reduced-oxygen copper-zinc (Cu-Zn) alloy filled dual-inlaid interconnect structure formed on a copper (Cu) surface formed by electroplating the Cu surface in a chemical solution, comprising the steps of:
- 5 providing a semiconductor substrate having a Cu surface formed in a via;  
providing a chemical solution;  
electroplating the Cu surface in the chemical solution thereby forming said a Cu-Zn alloy fill in the via and on the Cu surface,  
wherein said electroplating comprises using an electroplating apparatus,  
10 wherein said electroplating apparatus comprises:  
(a) a cathode-wafer;  
(b) an anode;  
(c) electroplating vessel; and  
(d) a voltage source, and  
15 wherein the cathode-wafer comprises the Cu surface,  
rinsing the Cu-Zn alloy fill in a solvent;  
drying the Cu-Zn alloy fill under a gaseous flow;  
annealing the Cu-Zn alloy fill formed in the via and on the Cu surface, thereby forming  
a reduced-oxygen Cu-Zn alloy fill having a uniform zinc distribution;  
20 planarizing the reduced-oxygen Cu-Zn alloy fill and the Cu surface, thereby completing  
formation of a reduced-oxygen Cu-Zn alloy filled dual-inlaid interconnect  
structure; and  
completing formation of the semiconductor device.

2. ~~(original)~~ A method, as recited in Claim 1,  
wherein the chemical solution is nontoxic and aqueous, and  
wherein the chemical solution comprises:

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at least one zinc (Zn) ion source for providing a plurality of Zn ions;  
at least one copper (Cu) ion source for providing a plurality of Cu ions;  
at least one complexing agent for complexing the plurality of Cu ions;  
at least one pH adjuster;  
at least one wetting agent for stabilizing the chemical solution, all being dissolved  
in a volume of deionized (DI) water.

3. (original) A method, as recited in Claim 2,

wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected  
from a group consisting essentially of zinc acetate  $((\text{CH}_3\text{CO}_2)_2\text{Zn})$ , zinc bromide  
 $(\text{ZnBr}_2)$ , zinc carbonate hydroxide  $(\text{ZnCO}_3 \cdot 2\text{Zn}(\text{OH})_2)$ , zinc dichloride  $(\text{ZnCl}_2)$ ,  
zinc citrate  $((\text{O}_2\text{CCH}_2\text{C}(\text{OH})(\text{CO}_2)\text{CH}_2\text{CO}_2)_2\text{Zn}_3)$ , zinc iodide  $(\text{ZnI}_2)$ , zinc L-  
lactate  $((\text{CH}_3\text{CH}(\text{OH})\text{CO}_2)_2\text{Zn})$ , zinc nitrate  $(\text{Zn}(\text{NO}_3)_2)$ , zinc stearate  
 $((\text{CH}_3(\text{CH}_2)_{16}\text{CO}_2)_2\text{Zn})$ , zinc sulfate  $(\text{ZnSO}_4)$ , zinc sulfide  $(\text{ZnS})$ , zinc sulfite  
 $(\text{ZnSO}_3)$ , and their hydrates.

4. (original) A method, as recited in Claim 2,

wherein the at least one copper (Cu) ion source comprises at least one copper salt  
selected from a group consisting essentially of copper(I) acetate  $(\text{CH}_3\text{CO}_2\text{Cu})$ ,  
copper(II) acetate  $((\text{CH}_3\text{CO}_2)_2\text{Cu})$ , copper(I) bromide  $(\text{CuBr})$ , copper(II) bromide  
 $(\text{CuBr}_2)$ , copper(II) hydroxide  $(\text{Cu}(\text{OH})_2)$ , copper(II) hydroxide phosphate  
 $(\text{Cu}_2(\text{OH})\text{PO}_4)$ , copper(I) iodide  $(\text{CuI})$ , copper(II) nitrate  $((\text{CuNO}_3)_2)$ , copper(II)  
sulfate  $(\text{CuSO}_4)$ , copper(I) sulfide  $(\text{Cu}_2\text{S})$ , copper(II) sulfide  $(\text{CuS})$ , copper(II)  
tartrate  $((\text{CH}(\text{OH})\text{CO}_2)_2\text{Cu})$ , and their hydrates.

5. (canceled)

Q3 6. (currently amended) A method, as recited in Claim 51,

wherein the cathode wafer comprises the Cu surface, and

wherein the anode comprises at least one material selected from a group consisting  
essentially of copper (Cu), a copper-platinum alloy (Cu-Pt), titanium (Ti),  
platinum (Pt), a titanium-platinum alloy (Ti-Pt), an anodized copper-zinc alloy

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(Cu-Zn, i.e., brass), a platinized titanium (Pt/Ti), and a platinized copper-zinc (Pt/Cu-Zn, i.e., platinized brass).

7. (original) A method, as recited in Claim 1,  
wherein said semiconductor substrate further comprises a barrier layer formed in the via  
under said Cu surface, and  
wherein the barrier layer comprises at least one material selected from a group consisting  
essentially of titanium silicon nitride ( $Ti_xSi_yN_z$ ), tantalum nitride (TaN), and  
tungsten nitride ( $W_xN_y$ ).
8. (original) A method, as recited in Claim 7,  
wherein said semiconductor substrate further comprises an underlayer formed on the  
barrier layer,  
wherein said underlayer comprises at least one material selected from a group consisting  
essentially of tin (Sn) and palladium (Pd), and  
wherein said Cu surface is formed over said barrier layer and on said underlayer.
9. (original) A method, as recited in Claim 8,  
wherein said underlayer comprises a thickness range of approximately 15 Å to  
approximately 50 Å,  
wherein said barrier layer comprises a thickness range of approximately 30 Å to  
approximately 50 Å,  
wherein said Cu surface comprises a thickness range of approximately 50 Å to  
approximately 70 Å, and  
wherein said Cu-Zn alloy fill comprises a thickness range of approximately 300 Å to  
approximately 700 Å.
10. (original) A method, as recited in Claim 1,  
wherein the annealing steps are performed in a temperature range of approximately  
150°C to approximately 450°C, and  
wherein the annealing steps are performed for a duration range of approximately 0.5  
minutes to approximately 60 minutes.

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11. (currently amended) A semiconductor device, having a reduced-oxygen copper-zinc (Cu-Zn) alloy filled dual-inlaid interconnect structure formed on a copper (Cu) surface formed by electroplating the Cu surface in a chemical solution, fabricated by a method comprising the steps of:

5 providing a semiconductor substrate having a Cu surface formed in a via;

providing a chemical solution;

electroplating the Cu surface in the chemical solution, thereby forming a Cu-Zn alloy fill in the via and on the Cu surface;

wherein said electroplating comprises using an electroplating apparatus,

10 wherein said electroplating apparatus comprises:

(a) a cathode-wafer;

(b) an anode;

(c) electroplating vessel; and

(d) a voltage source, and

15 wherein said cathode-wafer comprises the Cu surface,

rinsing the Cu-Zn alloy fill in a solvent;

drying the Cu-Zn alloy fill under a gaseous flow;

annealing the Cu-Zn alloy fill formed in the via and on the Cu surface, thereby forming a reduced-oxygen Cu-Zn alloy fill having a uniform zinc distribution;

20 planarizing the reduced-oxygen Cu-Zn alloy fill and the Cu surface, thereby completing formation of a reduced-oxygen Cu-Zn alloy filled dual-inlaid interconnect structure; and

completing formation of the semiconductor device.

12. ~~(original)~~ A device, as recited in Claim 11,  
wherein the chemical solution is nontoxic and aqueous, and  
wherein the chemical solution comprises:

at least one zinc (Zn) ion source for providing a plurality of Zn ions;

5 at least one copper (Cu) ion source for providing a plurality of Cu ions;

at least one complexing agent for complexing the plurality of Cu ions;

at least one pH adjuster;

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at least one wetting agent for stabilizing the chemical solution, all being dissolved in a volume of deionized (DI) water.

13. (original) A device, as recited in Claim 12,

wherein the at least one zinc (Zn) ion source comprises at least one zinc salt selected from a group consisting essentially of zinc acetate  $((\text{CH}_3\text{CO}_2)_2\text{Zn})$ , zinc bromide  $(\text{ZnBr}_2)$ , zinc carbonate hydroxide  $(\text{ZnCO}_3 \cdot 2\text{Zn}(\text{OH})_2)$ , zinc dichloride  $(\text{ZnCl}_2)$ , zinc citrate  $(\text{O}_2\text{CCH}_2\text{C}(\text{OH})(\text{CO}_2)\text{CH}_2\text{CO}_2)_2\text{Zn}_3$ , zinc iodide  $(\text{ZnI}_2)$ , zinc L-lactate  $((\text{CH}_3\text{CH}(\text{OH})\text{CO}_2)_2\text{Zn})$ , zinc nitrate  $(\text{Zn}(\text{NO}_3)_2)$ , zinc stearate  $((\text{CH}_3(\text{CH}_2)_{16}\text{CO}_2)_2\text{Zn})$ , zinc sulfate  $(\text{ZnSO}_4)$ , zinc sulfide  $(\text{ZnS})$ , zinc sulfite  $(\text{ZnSO}_3)$ , and their hydrates.

14. (original) A device, as recited in Claim 12,

wherein the at least one copper (Cu) ion source comprises at least one copper salt selected from a group consisting essentially of copper(I) acetate  $(\text{CH}_3\text{CO}_2\text{Cu})$ , copper(II) acetate  $((\text{CH}_3\text{CO}_2)_2\text{Cu})$ , copper(I) bromide  $(\text{CuBr})$ , copper(II) bromide  $(\text{CuBr}_2)$ , copper(II) hydroxide  $(\text{Cu}(\text{OH})_2)$ , copper(II) hydroxide phosphate  $(\text{Cu}_2(\text{OH})\text{PO}_4)$ , copper(I) iodide  $(\text{CuI})$ , copper(II) nitrate hydrate  $((\text{CuNO}_3)_2)$ , copper(II) sulfate  $(\text{CuSO}_4)$ , copper(I) sulfide  $(\text{Cu}_2\text{S})$ , copper(II) sulfide  $(\text{CuS})$ , copper(II) tartrate  $((\text{CH}(\text{OH})\text{CO}_2)_2\text{Cu})$ , and their hydrates.

15. (canceled)

16. (currently amended) A device, as recited in Claim 11~~15~~,  
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~~wherein the cathode wafer comprises the Cu surface, and~~

wherein the anode comprises at least one material selected from a group consisting essentially of copper (Cu), a copper-platinum alloy (Cu-Pt), titanium (Ti), platinum (Pt), a titanium-platinum alloy (Ti-Pt), an anodized copper-zinc alloy (Cu-Zn, i.e., brass), a platinized titanium (Pt/Ti), and a platinized copper-zinc (Pt/Cu-Zn, i.e., platinized brass).

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17. **(original)** A device, as recited in Claim 11,  
wherein said semiconductor substrate further comprises a barrier layer formed in the via  
under said Cu surface, and  
wherein the barrier layer comprises at least one material selected from a group consisting  
essentially of titanium silicon nitride ( $Ti_xSi_yN_z$ ), tantalum nitride (TaN), and  
tungsten nitride ( $W_xN_y$ ).
18. **(original)** A device, as recited in Claim 17,  
wherein said semiconductor substrate further comprises an underlayer formed on the  
barrier layer,  
wherein said underlayer comprises at least one material selected from a group consisting  
essentially of tin (Sn) and palladium (Pd), and  
wherein said Cu surface is formed over said barrier layer and on said underlayer.
19. **(original)** A device, as recited in Claim 18,  
wherein said underlayer comprises a thickness range of approximately 15 Å to  
approximately 50 Å,  
wherein said barrier layer comprises a thickness range of approximately 30 Å to  
approximately 50 Å,  
wherein said Cu surface comprises a thickness range of approximately 50 Å to  
approximately 70 Å, and  
wherein said Cu-Zn alloy fill comprises a thickness range of approximately 300 Å to  
approximately 700 Å.
20. **(original)** A semiconductor device, having a first interim reduced-oxygen copper-zinc  
(Cu-Zn) alloy fill formed on a copper (Cu) surface and a second interim reduced-oxygen  
Cu-Zn alloy fill formed on a Cu-fill, both films being formed by electroplating the Cu  
surface and the Cu-fill, respectively, in a chemical solution, comprising:  
a semiconductor substrate having a via; and  
an encapsulated dual-inlaid interconnect structure formed and disposed in said via, said  
interconnect structure comprising:  
at least one Cu surface formed in said via;

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a first interim reduced-oxygen Cu-Zn alloy fill formed and disposed on the at  
least one Cu surface;  
a Cu-fill formed and disposed on said interim reduced-oxygen Cu-Zn alloy fill;  
and  
a second interim reduced-oxygen Cu-Zn alloy fill formed and disposed on the Cu-  
fill.